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Dynamic Modeling of Multi-Regional Migration Processes: Ural Federal District Case Study

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Abstract: This article presents a dynamic model, that describes the labor force movement dynamics between Russian regions in continues time. The conducted analysis shows that migration model usually doesn't take into account more than two regions of migration and take into account a very limited number of resulting factors. The presented modification of our model allows to explain the dynamics of migration processes and their effects on regional economics both for regions of origin and attraction. The results of migration modeling in conditions of a closed system is presented on a graph and makes it possible to trace dependency between salaries levels, total labor force and the number of vacancies and unemployed people in several regions. Further research is planned to develop a model in terms of constructing unemployment and vacancies forecast and to create a model with elements of agent-based modeling to assess the impact of migration networks on the dynamics of inter-regional migration flows.

Keywords: labour migration prediction, economic theory of migration, economic effects, dynamic modeling, migration policy, labor market.

1. INTRODUCTION

Modern migration is a multifaceted phenomenon, which affects on all aspects of the society development. Processes of international migration have an significant impact on the demographic situation and the labor market in several regions. Consequences of international migration are very contradictory. The recent years dynamics allows us to observe growing migration mobility. It is necessary to highlight, that within the framework of economic systems migration processes are presented as direct and backward workforce flows presented in dynamics. In conditions of absence migration restriction barriers migration flows can support the balance of economic systems in conjugate regions. This is possible, because migration is usually directed from underdeveloped regions to regions with good developed infrastructure. Therefore decision management aimed at improving the overall quality of life is very complicated. All this determines the relevance of modeling interregional migration flows.

Migration modeling traditionally takes into account such economic factors push and pull workforce, the unemployment rate, the total number of vacancies, the number of floating population in a year. At the macroeconomic level, one of the main incentives for the migration is the presence or absence of high-paying jobs and employment opportunities on terms which are satisfactory to the individual. To expand the body of evidence for policy-makers we developed a multi-region migration-unemployment-wage model which goal is to predict the migration flows and the effects of migration on employment and wages.

In the context of increasing socio-economic and territorial polarization the unevenness migration flows in Russia increases. The role of internal migration in the formation of migration flows has grown since the mid-1990s. In the second half of the 2000s the scale of migration outflow decreased sharply (Table 1), but in general the population shift vector directed into regions characterized by a higher life level is stable. The migration exchange between the regions has its own leaders and outsiders. On the one hand, migration is one of the most important factors determining the socio-economic development. Migration flow has a significant curative effect on the demographic situation, and also softens Russia's demographic crisis.

Table 1. Migration increase (decrease) due to external and internal migration

Year	Kurgan region	Sverdlovsk region	Tyumen region	Chelyabinsk region
2000	-2034	7234	12740	8451
2001	-5585	4262	12483	389
2002	-4862	1430	10902	-1592
2003	-5165	263	4457	-3345
2004	-5419	5464	-210	-3254
2005	-5425	8711	641	436
2006	-5554	9508	2894	980
2007	-4719	8856	10107	4944
2008	-4078	9339	5185	5437

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2009	-2161	5870	8539	3698

Inflow of migrants improves the structure of the population, smoothes gender distortions and partially compensates for deficiencies in the supply of labor in the most popular age groups. On the other hand, migration flows are directly dependent on the socio-economic development of the area, first of all, from the labor market development, allowing to find a job and independently provide migrants income.

The diversity of migratory flows, their dependence on a number of factors and circumstances requires the creation of methodical foundations and implementation of qualitative analysis to identify trends for formation of a mechanism for effective migration flows management.

2. RELEVANT LITERATURE

Interstate and inter-regional labour migration, implying forced or voluntary movement of labour across national and regional borders, is widespread. Experts estimate that Russia has the second place in the world on number of undocumented migrants (e.g., Fasani 2009). Socio-demographic situation in Russia requires a redefining of the migration role in regional development. Migration processes have a significant impact on quality of life and economic situation in Russian regions.

Migration processes have a significant impact on quality of life and economic situation in the regions of Russia. Consequences of uncontrolled migration lead to the need to assess its impact on the shadow economy. At the same time, migrant workers have relevant employment opportunities in the formal sector of the economy (e.g. Naydyonov and Krivenko 2013). Interregional migration processes have a significant impact on the development of socio-economic situation in the regions of the Russian Federation. In recent years, a change in the level of demand and supply of labor in regional labour markets.

Several neoclassical economic studies of migration, such as Friedberg and Hunt (1995), Card (2001), Borjas (2003), Batishcheva, (2009), Strielkowski and Turnovec (2011), have developed migration models in which immigrant workers respond to cross-region differences in wages, migration costs, and the labor market situation in source and host regions. There is a growing body of literature that analyzes the effects of migration on the origin and destination countries and their labor markets (Borjas, 2003; 2009; Dustmann and Preston, 2011; Longhi et al., 2005; 2006; 2008; Ottaviano and Peri, 2006; 2008).

Strielkowski and Turnovec (2011) developed a two-country neoclassical economics model whereby the decision whether to migrate or stay is made by measuring the expected benefits against the relocation expenses. Batishcheva (2009) offered a two-country human capital model whereby a migration decision is made by a rational person assessing the net present value of relocating. According to Batishcheva's model, the migrant inflow increases the supply of labour and reduces the probability of finding gainful employment in a host region which is one of economic effects of immigration. These models, however, while describing a person's rational behaviour are incapable of predicting migration flows.

The well known gravity migration model (e.g., Kumo 2007) predicts the amount of migration between locations on the basis of the distance and regional populations. One of the assumptions of this model is that migration tend to take place over short distances, with the number of migrants decreasing as the distance over which they migrate increases. This is known as the distance-decay effect. The second assumption is that the number of migrants is determined by the size of locations of origin and destination; as the size of the settlements concerned decreases, the number of migrants will also decrease. The amount of migration is inversely proportional to the distance travelled, and directly proportional to the relative size of the locations of origin and destination.

Liu (2010) and Palivos (2009) investigate the effects of immigration on the native population within a search and matching model that describes how workers are matched to vacancies and how the wage rate is established in a situation of a successful job match. Within this framework they were able to account for the unemployment and wage effects stemming from the impact of immigration on the availability of jobs. Unlike Liu (2010), who considers only illegal and hence unskilled immigration, Palivos (2009) looks at the effects of the skill-biased immigration. To the best of our knowledge, the search and matching model is a good predictor of immigration effects, but it cannot be used for making forecasts regarding migration flows.

Vakulenko (2011) in her research work consider an econometric migration model based on the feature vectors of regions of arrival. Another approach used in the work of Orlov and, Suslin (2003) involves the study of the demographic problem of nonstationary distribution of population by age and social strata, taking into account migration flows. We also note the research works of Lutz, Crespo Cuaresma and Sanderson (2008), and Keyfitz and Caswell (2005) proposing a model describing the dependence of GDP growth on the efficiency of the labor force, level of education, age structure, quality-of-life index.

In this paper we present a dynamic model that can be used to predict the migration flows determined by wage differentials, distance and regional populations as well as the unemployment and wage effects resulting from the impact of migration on the availability of jobs in both the source and the host regions. One of the key features of this model distinguishing it from the previous literature is that we allow the simultaneous searches of potential migrants from more than one region to migrate to more than one region as in (Chereshnev and Vasileva 2013, Tarasyev 2013).

3. MIGRATION MODELING PROCESS

We construct a multi-region migration-unemployment-wage model. Time is continuous and begins at t=0. The modeling result consists in trajectories which describes the dynamics of

migration flows, and in the evaluation of the trajectories trend changes.

When considering migration by age groups it is necessary to notify that one of the most attractive factors for young people is the ability to get a good education, and later - a well-paid job. The decision of the migration depends on the level of public goods provision, such as early childhood education, primary school, health care, low crime rate, and infrastructure development. It is necessary to note the connection of migration to demography. The main causes of migration, according to official statistics and sociological surveys are associated with life cycle, which implies such events in a person's life as birth, education, military service, change of marital status and retirement. Important role in the dynamics of inter-regional workforce takes climatic and environmental conditions, the ethnic structure, culture and traditions in considered regions (e.g., Andrienko and Guriev 2004).

Migration smoothes the existing regional differences in the level and quality of life. Unemployment in major cities tend to be lower than in the country as a whole. Therefore, the migration from cities with high unemployment in the city with a lower balance will allow the labour market. Also migration responds to interregional differentiation in income (e.g., Vakulenko 2012).

One of the important factors increasing the flow of migrant workers into the region are the so-called migration networks, by which is meant a set of interpersonal ties that connect migrants, former migrants and non-migrants among themselves through kinship, friendship and social origin. Migration networks facilitate the dissemination of information about life conditions in different countries and regions, what increases the probability of employment. The dynamics of information dissemination is impossible to simulate through the use of agent-based modeling. Upon migration networks reach a certain development level, migration acquires the character of a self-sustaining process. The transition from individual independence in deciding whether to migrate to the group interdependence that is beneficial to all participants, took place in the framework of the new economics of migration. According to this theory, the decision is made by a potential migrant, under the influence of other members of his family, who does not change the place of work and residence. The purpose of migration in this situation becomes the maximization of an income of the whole community but not the individual. The community and the people will share with each other both costs and revenues from the migration of the community member. Also in the new economic theory of migration the importance of factors such as the level of income of the family environment is highlighted. Dissatisfaction with their social status at home may encourage family members to migrate in order to increase family income. In this paper, the effect of migration networks on the migration system is determined by the index $x_{jk}(t)$.

Due to development of a mathematical model, for an explanation the dynamics of inter-regional migration flows and their impact on the development of regional labour markets, let us consider the migration processes within the liberal model of development. This model is based on the paradigm of human rights, which claims the priority of human rights over the rights of the citizen. The right to free movement is one of the basic human rights in a democratic society. The liberal model of development implies the removal of all obstacles and barriers for the labour mobility that most clearly reflects both economic and socio-demographic components of interregional migration.

The model is a synthetic structure and connects the gravity model of trade, the problem of traffic optimization and Continuous-time Model of Logistic Growth developed by Verhulst. The model is divided into two parts and reflects the movement of the population between the Sverdlovsk region and other regions of the Ural Federal District. The data on unemployment, number of jobs, interregional migration flows are involved into the modeling process. For the simulation were used such factors as average wages, crime rate, quality of life in subjects of the Urals Federal District. These factors were combined into a Cobb–Douglas production function.

Because we use the logistic function, we can confidently say that the graphical representation of the forecast will be made in the form of *S*-shaped curve. Considering the graphical simulation result we can trace the dynamics of the vacancies saturation level in this subject by migration flows. The migration process is accelerated up to a certain point, called the point of inflection. After passing this point the migration process slows and eventually saturates at a certain equilibrium level.

By prediction of the migration movement from one region to others we use following equation:

$$\frac{dx_{jk}}{dt} = \frac{g \cdot x_{jk}(t) \cdot (u_j - \sum_{k=1} x_{jk}(t)) \cdot (v_k - \sum_{j=1} x_{jk}(t))}{r_{jk}} \quad (1)$$

$x_{jk}(t)$ − flow from the subject j to the subject k;

j=1,… ; k=1,… ;

g − "popularity" factor for the migration to chosen region, calculated by Cobb-Douglas production function;

$\frac{dx_{jk}}{dt}$ − flow rate between regions;

u_j − number of unemployed in the Sverdlovsk region;

v_k − number of vacancies in subjects of the Federal District;

$g \cdot x_{jk}(t)$ − multiplier of the logistic dynamics;

If we consider the migration from the regions of the Ural Federal District to another region, the equation changes as follows:

$$\frac{dx_{jk}}{dt} = \frac{x_{jk} \cdot (v_j - \sum_{k=1} x_{jk}(t)) \cdot (u_k - \sum_{j=1} x_{jk}(t))}{g \cdot r_{jk}} \quad (2)$$

In this case we will also change the notation:

v_j – number of vacancies in the Sverdlovsk region;

u_k – number of unemployed in subjects of the Federal District;

In case of considerable distance between subjects, distance becomes one of the resulting factors. The relation is inversely proportional: the longer the distance, the lower is the probability of an outcome of migrant workers to the given subject.

Because of universality of this model we can specify any number of sending and receiving regions and connections between them. Also we can take into account a large number of coefficients that describe the macroeconomic indicators of regions: the environment , the quality of life, crime rate, the average wages, the distance, the purchasing power of income. The graphs below show the dynamics of migration flows between the Sverdlovsk Region and the subjects of the Ural Federal District (Fig. 1).

Fig. 1. Ural Federal District

We have tested the model on the statistical database of the Ural Federal District. As we can see from the simulating results the model behaviour is quite similar to the real situation. The first graph (Fig. 2) illustrates an migration outflow from the Sverdlovsk Region, while the second graph (Fig. 3) depicts migration flows directed to the Sverdlovsk Region.

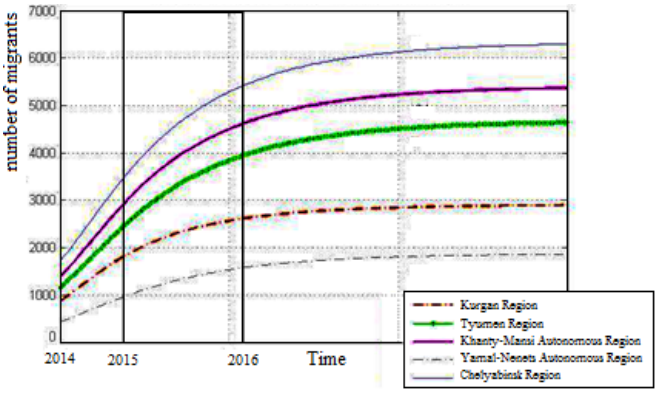

Fig. 2. Migration movement from Sverdlovsk Region to Ural Federal District subjects

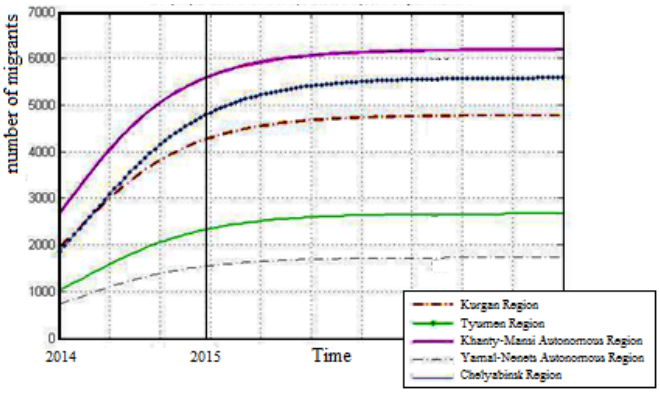

Fig. 3. Migration movement from Ural Federal District subjects to Sverdlovsk Region

The above model is universal, in the sense that you can specify any number of sending and receiving points and connections between them. Can also be taken into account a large number of coefficients describing the macroeconomic indicators regions: the environment, overall quality of life, crime, the average wage of the population, the distance, the purchasing power of cash income.

4. CONCLUSIONS

As we can see from the graphical interpretation of model simulation, the most attractive for migration from the Sverdlovsk region are the Chelyabinsk Region and Khanty-Mansi Autonomous Region. The number of vacancies in the Khanty-Mansi and Yamal-Nenets Autonomous Regions is close to saturation. Sverdlovsk, Chelyabinsk and Tyumen Regions differ by a constant positive level of migration growth. These regions are most preferred for migrant workers as the most economically developed and stable entities. Thus, in the territory of the Urals Federal District is an outflow from disadvantaged regions to better developed regions, which will continue until the disparities in socio-economic development between regions of Russia will be reduced. In modern Russia, an important driver of migration is the demand for labour in the large cities, it stimulates migration not only within regions, but also between different parts of

the country. Expansion of the labour market supply in the least socio-economically developed regions will reduce the unevenness of migration flows and the depopulation, which will create favourable conditions for the development of the territory.

For the simulation purposes we used the current data on unemployment. Further research is planned to develop a model in terms of construction of the level of unemployment and vacancies forecast functions of and the subsequent inclusion of these indicators into the model as time-dependent functions. This modification will greatly improve the overall quality of this model. Modeling of parameters dynamics, that are taken into account in this model, will increase the prediction time interval with the prediction accuracy around 97%. At the same time, it is assumed that the system described in this model will have a self-regulating character. It is expected to create a model with elements of agent-based modeling to assess the impact of migration networks on the dynamics of inter-regional migration flows.

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